

INSTRUCTION MANUAL



MODEL 1660

INTRODUCTION

This calculator will provide you with rapid, accurate solutions to a wide range of problems. It is an electronic slide rule with eight digit accuracy plus the standard calculator functions of addition, subtraction, multiplication and division. A memory stores intermediate results for easy recall. Automatic constant retains a number for repetitive operations plus integer powers of a number without need of a special key or switch.

We suggest that you read through this booklet with your calculator in hand to acquaint you with its many features.

HIGHLIGHTS

- Fully floating decimal
- Algebraic operation
- Scientific notation
- Memory register
- Trigonometric functions
- Large bright display
- Eight digit accuracy
- Convenience functions
- Auto Constant feature
- Battery and AC operation

KEYBOARD

The Keyboard consists of an On-Off Switch, a function key and 18 data entry and operation keys. All of these keys have a primary function, and 17 have an auxiliary function. Selection of an auxiliary function is accomplished by depressing the **[F]** key followed by the key labelled with the desired auxiliary function. Activation of the function key is indicated by display of the character F in the leftmost position of the display. To cancel activation of the function key merely depress it a second time.

DISPLAY

The display consists of 9 positions or digits. Position 1 (left) is reserved for a negative sign and/or an indication symbol. The remaining eight positions display an eight digit floating decimal number or a five digit mantissa with a two digit exponent and sign for scientific notation. All eight positions are used to display the internal eight digit mantissa when using the "CN" function. Indication symbols which may appear in position 1 are as follows:

- negative number
- E error
- I memory in use
- F F mode (shift key)

Clearing Functions

The calculator automatically clears all registers, including memory, when it is first turned on. Entered data or results stored in the x and y registers or memory are cleared as follows:

[C/CE]

when depressed once:

- 1) During number entry; clears the display
- 2) Clears error indication and conditions the calculator for a new entry
- 3) After completion of an operation; clears all registers except memory.

[C/CE]

when depressed twice:

- 1) Clears calculator of all numbers
- 2) Zero is displayed.
- 3) Memory is not effected.

[F]

[MC]

clears the memory register.

Data Entry

0 thru **9**

.

F **π**

EE**X**

-

Operation Keys

+

=

x

\div

=

Numerical entry

Defines the decimal point on the first depression in number entry

Enters the constant π .

Conditions the calculator to receive an exponent. The last three display digits are cleared. The eight digit mantissa is preserved internally.

Enters a negative mantissa or exponent when it precedes numerical entry.

Operation command keys are used between entry of numbers to be combined by the selected operation. They terminate numerical entry, store the selected operation, and perform a possible preceding operation.

Terminates numerical entry and performs the previously stored operation. Conditions the calculator for new operations including use of the displayed result or the constant.

MATHEMATICAL FUNCTIONS OF ONE VARIABLE

Each function is invoked by depression of the function key {F} followed by the desired operation key. The result replaces the number operated on.

F **$1/x$**

Reciprocal

F **\sqrt{x}**

Square root

F **$\ln X$**

Natural logarithm

F **a^x**

Antilogarithm; Base 'e' exponential

F **\sin**

Sin

F **\cos**

Cosine

F **\tan**

Tangent

F **\sin^{-1}**

Arc sine

F **\cos^{-1}**

Arc cosine

F **\tan^{-1}**

Arc tangent

NOTE: With the exception of the Square Root Function (\sqrt{x}) all upper case functions use both the x and y registers, deleting any previous contents stored.

Function mode is cleared by depression of the selected operation key or a second depression of the function key.

Notation Conversion

The calculator automatically selects the correct notation, standard or scientific, to take best advantage of the eight digit plus sign display. When scientific notation is automatically selected, the eight digit mantissa is preserved internally with the five highest order digits displayed. The **cn** function allows examination of the additional three digits of the mantissa at any time.

Automatic conversion from standard to scientific notation takes place for values of x as follows:

$$|x| \geq 10^5$$

$$|x| \leq 10^{-4}$$

The **cn** Function displays all digits of the mantissa and the decimal point if it falls in the range of the eight digit display. Leading and trailing zeros are not displayed.

MEMORY OPERATION

The calculator memory register is used to store and retrieve intermediate results of calculations as in calculating a sum of products. A feature of this calculator is that memory operations may be performed at any time without interfering with a sequence of entries. Memory use is indicated by **(1)** in the leftmost display position. Depression of the function key **F** followed by the desired memory function key will invoke the following memory operations.

F **M+**

Adds the displayed number to the number in memory. Display is unchanged.

F **M-**

Subtracts the displayed number from the number in memory. Display is unchanged.

F **$\times \leftrightarrow M$**

Exchanges the number in memory with the number in the display.

F **MR**

Recalls the number in memory into the display.

F **MC**

Erases the number in memory and clears the memory-in-use indicator **(1)**.

∞ OPERATING FEATURES

Standard or Scientific Notation Data Entry and Display

- Automatic selection of correct notation
- Displays 8 digit floating decimal signed number or 5 digit signed mantissa plus 2 digit exponent
- CN function displays full 8 digit internal value of mantissa including decimal point if in the range of the display

EXAMPLE:

<u>Value</u>	<u>Possible Entry</u>	<u>Display</u>	<u>CN function</u>
123.45678	1.2345678, EEX, 2	1.2345 02	123.45678
.000012345	1.2345, EEX, -, 5	1.2345-05	12345

Algebraic Problem Entry

Example: 2 \times 3 $+$ 4 $=$ 10.; actual key sequence

Chain (continuous) Calculations

Example: 2 \times 4 $+$ 7 \div 5 $=$ 3.

Example: Number Entry and Recall

<u>Enter</u>	<u>Display</u>	<u>Comment</u>
1.2345678	1.2345678	Eight digit mantissa entered Last three digits reserved for exponent entry.
$\boxed{\text{EEX}}$	1.2345 00	
1	1.2345 01	
2	1.2345 12	Numerical entry terminated and multiply command stored.
$\boxed{\times}$	1.2345 12	
2	2	
$\boxed{=}$	2.4691 12	Entered numbers are multiplied 'F' indicates function mode
$\boxed{\text{F}}$	F2.4691 12	
$\boxed{\text{CN}}$	24691356	
$\infty \boxed{\text{F}} \boxed{\text{CN}}$	2.4691 12	Eight digit mantissa is displayed. Decimal point is outside of range of the display. Scientific notation is recalled.

Example: Automatic conversion to scientific notation.

Enter	Display	Comment
88888888	88888888.	Enter a large number
\times	88888888.	
2	2.	
=	1.7777 08	Automatic conversion to scientific notation.
F CN	17777777	The eight digit internal mantissa is displayed. Decimal point is out of range of the display.
F CN	1.7777 08	Scientific notation is recalled.
Example: Converting between scientific and standard notation		
Enter	Display	Comment
.0000123	0.0000123	
=	1.23 -05	Number is automatically converted to scientific notation
11111111	11111111.	Enter a new number; clearing is not necessary after [=] key
\times	11111111.	
100	100.	
=	1.1111 09	Result is greater than 10^9 ; scientific notation is automatically selected.

FUNCTION ERRORS

Certain mathematical operations and functions cannot be executed over the full range of numbers which may be entered. The following table lists each function of this calculator and the allowable range. In all cases entry beyond eight significant digits is ignored. The error symbol displayed for all functions, is E O.

Function	Range
$x + y$	$1 \times 10^{-99} \leq x \leq 9.9999999 \times 10^{99}$
$x - y$	$1 \times 10^{-99} \leq x \leq 9.9999999 \times 10^{99}$
$x \times y$	$1 \times 10^{-99} \times 9.9999999 \times 10^{99}$
$x \div y$	$y \neq 0; 1 \times 10^{-99} \leq x \leq 9.9999999 \times 10^{99}$
\sqrt{x}	$x > 0$
$\ln x$	$x > 0$
e^x	$x < 100 \text{ LN } 10$
$\sin(x)$	$0^\circ \leq x \leq 90^\circ$
$\cos(x)$	$0^\circ \leq x \leq 90^\circ$
$\tan(x)$	$0^\circ \leq x < 90^\circ$

Function	Range
\sin^{-1} (x)	$0 \leq x \leq 1$
\cos^{-1} (x)	$-1 \leq x \leq 1$
\tan^{-1} (x)	$0 \leq x < \tan 10^{50}$
$1/X$	$x \neq 0$

A calculation can be performed to produce a result outside the permissible range of the calculator. If the result is greater than 9.999999×10^{99} an overflow error will be indicated by "E" in the display.

ACCURACY

Errors which affect the accuracy of your calculator stem from two sources. Truncation errors are the result of rounding the mantissa of a number which is longer than eight digits. Algorithmic errors are the result of sometimes limited precision of constants used in a process and may contribute to the overall accuracy of a calculation. Certain functions become less accurate for some ranges of input values so that each is capable of different degrees of accuracy.

The following chart summarizes error estimates which are indicative of the error expected to be accumulated from all causes and represents the maximum error for each function.

Example: $\sqrt{3}$ Display 1.7320508

For \sqrt{x} , the chart defines error as "1 cnt (count) in D8". The maximum error is ± 1 in this digit (the 8 on the right).

Function	Entry	Maximum Mantissa Error
$x + y$		1 cnt in D ₈
$x - y$		1 cnt in D ₈
$x \times y$		1 cnt in D ₈
$x \div y$		1 cnt in D ₈
\sqrt{x}		1 cnt in D ₈
nX		1 cnt in D ₄
e^x		1 cnt in D ₄
\sin (x)	$0^\circ \leq x \leq 90^\circ$	1 cnt in D ₄
\cos (x)	$0^\circ \leq x \leq 90^\circ$	1 cnt in D ₄
\tan (x)	$0^\circ \leq x \leq 89.99$	1 cnt in D ₄
	$89.99 < x \leq 89.999$	2 cnt in D ₄
	$89.999 < x \leq 89.999999$	7 cnt in D ₂
\sin^{-1} (x)		1 cnt in D ₄
\cos^{-1} (x)		1 cnt in D ₄
\tan^{-1} (x)		1 cnt in D ₄
$1/x$		1 cnt in D ₈

OPERATION

Calculations	examples	Enter
Addition & Subtraction	$500 - 25 + 50 - 30 = 495$ $123 + 456 + 789 = 1,368$ $45.6 - 14.7 - 78.9 = -48.$ $-1.23 - 5.67 + 6.78 = -0.12$	$500 \text{ [-] } 25 \text{ [+] } 50 \text{ [-] } 30 \text{ [=] } 495$ $123 \text{ [+] } 456 \text{ [+] } 789 \text{ [=] } 1368$ $45.6 \text{ [-] } 14.7 \text{ [-] } 78.9 \text{ [=] } -48.$ $-1.23 \text{ [-] } 5.67 \text{ [+] } 6.78 \text{ [=] } -0.12$
Repeat addition	$6 + 6 + 6 + 6 + 6 = 30$ $5 + 5 + 5 + 5 + 5 = 25$	$6 \text{ [+] } \text{ [=] } \text{ [=] } \text{ [=] } \text{ [=] } 30$ $5 \text{ [+] } \text{ [=] } \text{ [=] } \text{ [=] } \text{ [=] } 25$
Multiplication & Division	$2.2 \times 3.3 = 4.4 \times 5.5 = 175.692$ $45.6 \div 12 = 3.8$ $123.45 \div (-15) = -8.23$	$2.2 \text{ [x] } 3.3 \text{ [x] } 4.4 \text{ [x] } 5.5 \text{ [=] } 175.692$ $45.6 \text{ [÷] } 12 \text{ [=] } 3.8$ $123.45 \text{ [÷] } 15 \text{ [=] } -8.23$

Power calculation	$2^2 = 4$ $2^3 = 8$ $2^4 = 16$	$2 \text{ [x] } 2 \text{ [=] } 4.$ $\text{ [=] } 8.$ $\text{ [=] } 16.$
Constant calculation	$2 + 3 = 5$ $4 + 3 = 7$ $5 + 3 = 8$	$2 \text{ [+] } 3 \text{ [=] } 5.$ $4 \text{ [+] } 3 \text{ [=] } 7.$ $5 \text{ [+] } 3 \text{ [=] } 8.$
	$30 - 5 = 15$ $30 - 5 = 25$ $40 - 5 = 35$	$20 \text{ [-] } 5 \text{ [=] } 15.$ $30 \text{ [-] } 5 \text{ [=] } 25.$ $40 \text{ [-] } 5 \text{ [=] } 35.$
	$99.99 \times 11.11 = 1110.8889$ $99.99 \times 33.33 = 3332.6667$ $99.99 \times 44.44 = 4443.5556$	$99.99 \text{ [x] } 11.11 \text{ [=] } 1110.8889$ $33.33 \text{ [x] } 3332.6667$ $44.44 \text{ [x] } 4443.5556$
	$100 \div 4 = 25$ $200 \div 4 = 50$ $400 \div 4 = 100$	$100 \text{ [÷] } 4 \text{ [=] } 25.$ $200 \text{ [÷] } 4 \text{ [=] } 50.$ $400 \text{ [÷] } 4 \text{ [=] } 100.$
Trigonometric & Inverse trigonometric functions	$1) \sin 30^\circ = 0.5$ $2) \cos 60^\circ = 0.5$ $3) \tan 45^\circ = 1.0$ $4) \sin^{-1} 0.5 = 30$	$30 \text{ [F] } \text{ [sin] } 0.5$ $\text{ [F] } \text{ [=] } 30 \text{ [F] } \text{ [cos] } 0.5$ $45 \text{ [F] } \text{ [tan] } 1.$ $.5 \text{ [F] } \text{ [sin }^{-1} \text{] } 30.$

Exponential function	$e^1 = 2.7182$	1 [F] [e^x] 2.7182
Logarithmic function	$\ln 5 = 1.6094$	5 [F] [ln] 1.6094
Reciprocal calculation	$\frac{1}{5^2} = 0.04$ $\frac{1}{5 \times 9 + 5} = 0.02$	5 [x] [=] [F] [1/x] 0.04 5 [x] 9 [+] 5 [=] [F] [1/x] 0.02
Square root	$\sqrt{169} = 13$	169 [E] [√x] 13.
Extraction	$\sqrt{1456 \div 3971 \times 20} = 130.61393$	456 [÷] 397 [x] 20 [=] [F] [√x] 130.61393

Example 1 Hyperbolic function, $\sinh x$

$$(\text{Formula}) \sinh x = \frac{1}{2} (e^x - e^{-x}) \quad x = 0.5$$

Steps	Enter	Display	Note
1	[MC] .5 [F] [e^x] [F] [M+]	1.6487	e^x Memory lamp on
2	[F] [1/x] [F] [M-]	0.6065384	$-e^{-x}$ (memory $x^x - e^{-x}$)
3	[F] [MR] [÷] 2 [=]	0.5210607	$\frac{1}{2} (x^x - e^{-x})$ Answer

Ex. 2 $(1.5)^{2.5} = ?$

Steps	Enter	Display
1	1.5 [F] [ln]	0.40546
2	[x] 2.5 [=]	1.01365
3	[F] [e^x]	2.7556

Ex. 3 $\sin 30^\circ \times \cos 18^\circ = ?$

Steps	Enter	Display	Note
1	[C] [CM] 30 [F] [sin]	0.5	
	[F] [M+]	0.5	Memory indicator on
2	18 [F] [cos] [x]	0.95106	
3	[F] [MR] [=]	0.47653	Answer

Ex. 4 $\tan^{-1} \frac{1}{\sqrt{1+2^2}}$

Steps	Enter	Display
1	2 [x] [=]	4.
2	[+] 1 [=]	5.
3	[E] [√x]	2.2360679
4	[F] [1/x]	0.4472136
5	[F] [tan⁻¹]	24.094

NOTES

SAMPLE PROBLEMS

The following problems will illustrate several of the many practical uses of your calculator. Each will acquaint you with some of the various functions of the calculator. Our methods of solution represent one way of solving a particular problem; you may prefer to solve the problem in a different manner and still obtain a correct answer.

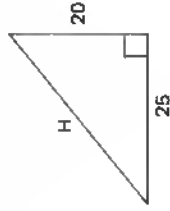
Example 1: Find the length of H

Solution: $H = \sqrt{x^2 + y^2}$ (Pythagorean theorem)

where $x = 25$, $y = 20$

Answer: 32.015621

Computation: 25 x = F 20 + = F MR F \sqrt{x}



20 Example 2: $5N^2 - 6N - 11$; Solve for N

Solution: The typical solution for a second order algebraic equation is the quadratic formula

$$\text{where } N = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

Where $a = 5$, $b = -6$, $c = -11$

Answer: Root 1 $\rightarrow N = 2.2$. Root 2 $\rightarrow N = -1$

Computation:

Enter	Display	Comment
6 \times = F M+	36.	Store b^2
C/CE - 4 \times 5 \times - 11 +	220.	$-4ac$
F MR = F \sqrt{x}	16.	$\sqrt{b^2 - 4ac}$
CM F M-	16.	Store $\sqrt{b^2 - 4ac}$ for Root 2
+ 6 \div 2 \div 5 =	2.2	Root 1
F MR + 6 \div 2 \div 5 =	-1	Root 2

Example 3: Find the angle, in degrees, whose sine is $\sqrt{3}/2$

Enter	Display	Comment
3	3.0	
F \sqrt{x}	1.7320508	Square root of 3.
\div	1.7320508	Division operation is stored:
2	2.	1.7320508 is saved.
=	0.8660254	Division operation is executed.
F \sin^{-1}	60.001	Answer in degrees.

Example 4: Find LOG x; x = 2.7182

Enter	Display
2.7182	
$\boxed{\text{F}} \boxed{\ln\text{X}}$	0.99992
$\boxed{\div}$	0.99992
2.30259	2.30259

$\boxed{=}$ 0.4342588

Example 5: Find y^z ; y = 4; z = 2.5

Enter	Display
$\boxed{4}$	4.
$\boxed{\text{F}} \boxed{\ln\text{X}}$	1.3863
$\boxed{\times}$	1.3863
$\boxed{2.5}$	2.5
$\boxed{=}$	3.46575
$\boxed{\text{F}} \boxed{e^x}$	32.

Comment

Enter natural log base, e
Natural log of number 'e'

Conversion factor between natural log and log to the base of 10.
Log₁₀ of the natural log base 'e'

Comment

Natural log of 4

Enter exponent
Natural log of 4^{2.5}
Answer

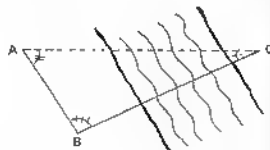
Surveying

Example: To extend a survey line across a river it may not be practical to measure directly across.

Angle A is 73.3°

Angle B is 88.5°

AB is 54 Feet



Solution: The angle at C will be $180^\circ - A - B = 18.2^\circ$

$$\text{By the law of sines, } \frac{AC}{AB} = \frac{\sin B}{\sin C}$$

Answer: $AC = (\sin 88.5 \div \sin 18.2) \times 54 = 172.8 \text{ Feet.}$

Computation:

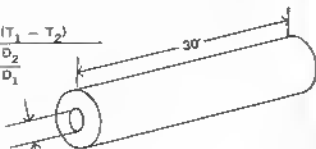
Enter	Display	Comment
18.2, $\boxed{\text{F}} \boxed{\sin} \boxed{\text{F}} \boxed{M+}$	0.31233	Calculate and store sin 18.2
88.5, $\boxed{\text{F}} \boxed{\sin} \boxed{\div}$	0.99965	Calculate sin 88.5
$\boxed{\div} \boxed{M+} \boxed{\times} \boxed{54} \boxed{=}$	172.83353	Answer

Mechanical Engineering

Example: What is the heat lost from 30 ft. of 2.375 inch diameter pipe covered with $\frac{1}{2}$ inch of an insulating material having a thermal conductivity of 0.0375 BTU/hi/ft.²/F.

The inner and outer surface temperatures are 380°F and 80°F respectively.

Solution: $Q = \frac{2\pi L K (T_1 - T_2)}{\ln \frac{D_2}{D_1}}$



Where: $K = 0.0375 \text{ BTU/hi/ft.}^2/\text{F.}$

$L = 30 \text{ ft.}$

$D_1 = 2.375$

$D_2 = 4.375$

$T_1 = 380$

$T_2 = 80$

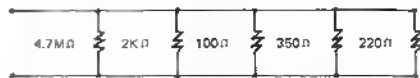
Answer: $Q = 3471 \text{ BTU/hi}$

Computation:

Enter	Display	Comment
4.375, \div , 2.375, [=] [F] [lnX]	0.6109	$\ln \frac{D_2}{D_1}$ displayed
[F] [M+]	0.6109	Save in memory
380, [-], 80, [x], 0.0375, [x]	11.25	
30, [x], [F] [M+], [x], 2 [=]	2120.575	
[F] [MR] [=]	3471.2309	Answer

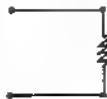
Electronics

Example Find the equivalent of the following parallel resistance.



Solution:

$$R_{\text{equiv.}} = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \dots}$$



$$= \frac{1}{\frac{1}{4.7 \times 10^6} + \frac{1}{2 \times 10^3} + \frac{1}{10^2} + \frac{1}{350} + \frac{1}{220}}$$

Answer: 55.857496 Ω

Computation:

Enter	Display
4.7 [EX] 6 [F] [1/x] [F] [M+]	2.1276 -- 07
2 [EX] 3 [F] [1/x] [F] [M+]	5. --04
1 [EX] 2 [F] [1/x] [F] [M+]	0.01
350 [F] [1/x] [F] [M+]	0.0028571
220 [F] [1/x] [+], [F] [MR] [=]	0.0179028
[F] [1/x]	55.857156

Example 1: Finance — What will the monthly payment be on a \$100,000 loan, borrowed for three years at 13% per year?

$$M = P \frac{i(1+i)^n}{(1+i)^n - 1}$$

Where: M = monthly payment

P = principal (\$100,000)

i = monthly interest rate (annual rate $\{.13/12\}$)

n = number of periods = 12 months \times 3 years = 36

Answer: $3369.8112 = 3,369.81$

Computation:

$$.13 \div 12 + 1 = F \ln X \times 36 = F e^X F (M+ - 1 = F 1/X \times 1$$

$$\boxed{\text{EEX}} 5 \times .13 \div 12 \times F \boxed{\text{MR}} =$$

Example 2: Inventory Management — If the demand for widgets is uniform and at the rate of 2,000 per month, the setup cost for a lot of widgets is \$25,000, and the cost of holding a widget in inventory for a month is \$1.75, in what size lots should widgets be manufactured?

$$Q = \sqrt{\frac{2KM}{h}}$$

Where: Q = "Economic Order Quantity"

K = setup cost = 25000

M = demand per unit time = 2000

h = holding cost per unit time = 1.75

Answer: $7559.2894 = 7559$ widgets

27 Computation: $2 \times 25000 \times 2000 \div 1.75 = F \sqrt{x}$

CLEAR ENTRY FEATURE

NOTES

Correcting mistakes When a wrong number is entered, press the **C/CE** key to clear the entry and enter the correct number.

Ex. 1 123 + 455 (mistake) 456 (correct)

123 + 455 CE 456 = 579
 └──────── wrong entry

Ex. 2 456 X 469 (mistake) 369 (correct)

456 X 469 CE 369 = 168264
 └──────── wrong entry

POWER SOURCE

We recommend the use of a 9V Alkaline battery (Mallory MN1604 or equivalent) since this will provide a brighter display and longer battery life.

Your calculator is fitted with an adaptor socket which allows operation with any suitable AC/DC calculator mains adaptor.